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Water and sediment quality and plankton diversity of Posna *beel*, Tangail

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Abstract. Physiochemical studies on water and sediment quality and plankton diversity of Posna *beel*, Kalihati, Tangail were conducted during 2003-2005. Surface water temperature was minimum (16 ^{0}C) during winter and maximum (33 ^{0}C) during summer. Water transparency varied from 25 cm in summer to 189 cm in winter. Other water quality parameters like pH (7.2-8.0), DO (6.6-9.6 mg/L), free CO_2 (5-13 mg/L), alkalinity (28-51 mg/L), total solids (7-123 mg/L), BOD ((2.70-5.43 mg/L), COD (5.20-8.15 mg/L), total hardness (51-68 mg/L), NH_3 (0.01-0.07 mg/L), NO_3-N (0.15-0.48 mg/L) were found to be suitable for freshwater fishes. The *beel* sediment was rich in nutrient and contained a high amount of organic matter (3.84-6.25 %). Some essential compounds like iron (417-440 µg/g), manganese (23.93-55.63 µg/g), copper (8.0-11.63 µg/g), magnesium (1.83-2.56 meq/100 g) were also found to be high. A total of 48 genera of phytoplankton and 41 genera of zooplankton were recorded. Dinoflagellate bloom was observed throughout the study period. Shannon-Weiner biodiversity indices were found to be higher during monsoon for zooplankton while phytoplankton abundances showed no such specific relationship with season. The physicochemical and biological parameters indicate that the *beel* was eutrophic in nature.

Introduction

The inland waters of Bangladesh occupy an area of 44.22 million ha. The open waters comprise of 1.032 million ha of rivers, canals and estuaries and 0.114 million ha of depression such as the *beels* and *haors* (BBS, 2001). *Beels* are the deepest region of natural depression within the floodplains and retain water round the year or greater part of the year. The open water resources till date supply a greater proportion of fish for the people while the *beel* fisheries alone contribute 5.85% to the total annual catch (Dash, 2004)

HYV Boro cultivation is common in catchment areas of the *beel*. Due to indiscriminate use of fertilizer and pesticides, the environment of the *beel* is undergoing gradual changes. On an average, farmers apply 0.2 liter pesticide per hectare in rice fields and 1.12 liters/ha in vegetable fields, respectively (Ahmed,

2004). Farmers mainly use urea, TSP, potash and zinc fertilizers in the crop fields as well as pesticides like Basudin, Diazinon, Furadan in the rice fields around the *beel* that are toxic to aquatic animals (CPP, 1992). The run-off water coming from the farmers' fields always carries a proportion of the applied fertilizers and pesticides and thereby pollute the *beel* water (Ahmed, 1985). Severe depletion of fisheries resources of the *beels* is reported due to water pollution. Although the *beels* are important among the open water bodies for the supply of fish in Bangladesh but only a few studies have been made on the water quality and biological aspects of the *beel* (Zaman, 1991, Ehshan, 1997, Kabir *et al*. 1997, Hossain, 1998, Saha and Hossain, 2002).

Systematic studies on agrochemicals used in *beels* and in the surrounding areas and their impact on water quality and aquatic organisms have not been carried out in Bangladesh. Only a survey is known on agrochemicals carried out by Compartmentalization Pilot Project (CPP, 1992) in different *beels* of Tangail. The present investigation was conducted to determine the quality of water and sediments and plankton diversity of Posna *beel,* Kalihati, Tangail.

Materials and methods

Study area

The Posna *beel* is an important perennial water body in Kalihati *upazilla* of Tangail District. The *beel* covers an area of 9.0 ha in summer (May-June) and winter (January-February) and 121.5 ha in monsoon (July-August). The *beel* is flooded every year during monsoon. The *beel* is the main source of fish to the villagers around.

Data collection

Three sites were arbitrarily selected for the collection of water and sediment samples. Water and sediment samples were collected at mid-day, four times in a year on April 17 in 2004 and 2005, August 15 in 2003 and 2004, October 22 in 2003 and 2004, and December 31 in 2003 and 2004. Plankton samples were collected in the morning and evening at three months intervals from the three selected spots by filtering 100 liters of water through a plankton net (Bolting silk No.20 having mesh size of 0.076 mm).

Information on the uses of agrochemicals was collected by a structured questionnaire survey from 190 farmers of the three villages. Data were analyzed using Microsoft Excels Program. The pesticide residue analysis was done at the Atomic Energy Commission Lab, Savar, Dhaka. Three groups of pesticides such as organochlorine, organophosphate, and carbamate were analyzed with GC-ECD and

HPLC. Different chemical parameters of the *beel* water were monitored as follows : pH by a portable pH meter (HANNA Instrument Co.); total alkalinity, total hardness, DO, free CO_2, Chloride, BOD and COD after Welch (1948), APHA (1997), Winkler (1981) and Kudesia (1980); nitrate after (Chopra and Kanwar, 1976); and phosphate and ammonia after (Boltz, 1958). Eh and rH2 were calculated following Gautam (1990) and Mukherjee (1996). The *beel* sediment was analyzed at the regional laboratory of the Soil Resource Development Institute (SRDI), Rajshahi. Identification of plankton was made following Ward and Whipple (1959), Presecot (1962) and, Bhouyian and Asmat (1994).The quantitative enumeration of plankton was carried out by a Sedgwick rafter counting chamber and expressed as cells per liter (unit/liter). The abundance of plankton groups were calculated according to the formula of Welch (1948).

Plankton diversity was estimated using the Shannon-Weiner biodiversity Index (H) (Shannon, 1948). The cumulative abundance of phytoplankton and zooplankton was estimated after Lambshead *et al*. (1983). The K-dominance analysis was performed with the CAP (Community Analysis Package) software (Seaby *et al*., 2004).

Similarities in the species assemblages in Posna *beel* were summarized in two-dimensional space using non-parametric multidimensional scaling (MDS) ordinations following a strategy proposed by Clarke (1993). The MDS analysis was performed with the CAP (Community Analysis Package) software (Seaby *et al*., 2004).

Results and discussion

Sources of water pollution

According to interviewed farmers (62.4 %), agro-chemicals used in HYV Boro field was the main source of water pollution in Posna *beel*. In their opinion, rotten aquatic weeds and decomposed organic matters are the second and third major causes of water pollution, respectively.

Farmers in the project area used more nitrogenous chemical fertilizer (urea and NH_4Cl) than the government recommended dose (113.14 kg/acre urea against the government recommendation dose of 87.0 kg/acre). Farmers were also found to apply another nitrogenous fertilizer NH_4Cl in their paddy fields. These two chemical fertilizers were reported to be the major causes of skin irritation (locally called '*Pani Kamor*'). On the other hand the farmers were found to use TSP (42.52 kg/acre), MP (13.29 kg/acre) and Gypsum (0.84 kg/acre) at the dose which is lower than the government recommended dose (Fig. 1).

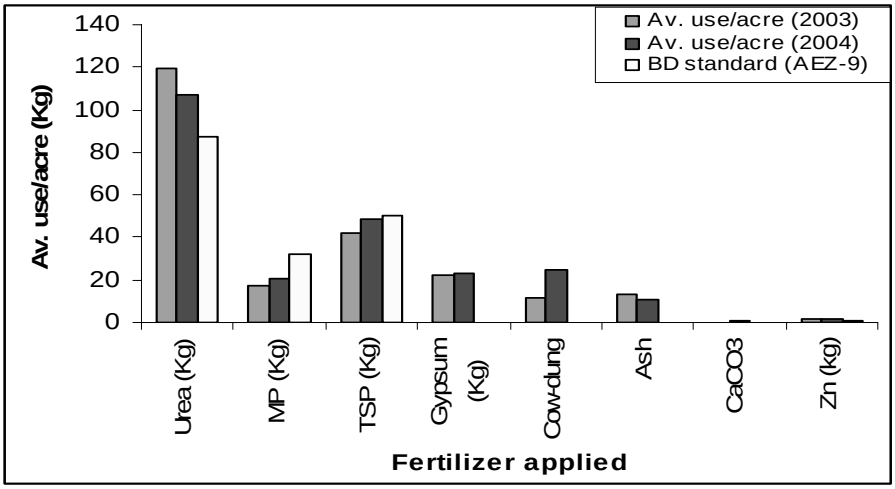

Fig. 1. Pattern of fertilizer use by farmers during 2003 and 2004 in the three surveyed villages around the Posna *beel*.

Basudin and Furadan were the major pesticides used in the HYV rice fields around the Posna *beel*. Chemically both the pesticides are organophosphates and contain diazinon. However, a little amount of liquid malathion is also used in the project area, which is a carbamate and contain carbofuran. Pesticide use pattern in the surveyed three villages around the Posna *beel* is shown in Fig. 2.

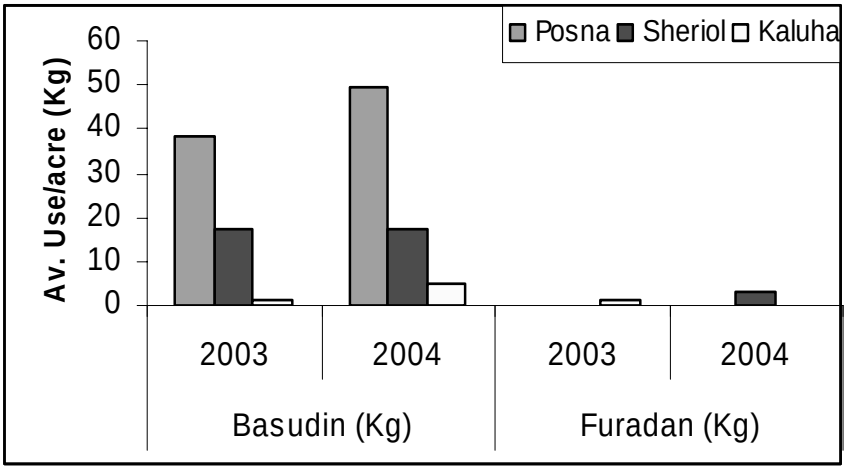

Fig. 2. Pesticide use pattern in three villages in study area.

Water Quality

The physico-chemical qualities of water of Posna *beel* are shown in Table 1. Seasonal variation in surface water temperature (16 to 33^{o}C) was noticed, higher in summer, monsoon and post-monsoon while lower in winter probably due to variation in solar radiation. The higher value of total solids (123.33 mg/L) was recorded in summer while lower (7 mg/L) in winter probably due to variation in turbidity of water resulted from suspended materials.

The pH level of water (6.8-8.0) varied from almost neutral to moderately alkaline. Ellis (1937) reported that a pH range of 6.7-8.4 is suitable for the growth of aquatic biota. Seasonal variation was observed in free CO_2 content in water (5-13 mg/L), the lower values might be the result of increased rate of photosynthesis by aquatic weeds coupled with low rate of respiration by aquatic organisms and decreased rate of decomposition of organic matter. Total alkalinity of water varied from 34-51 mg/L. Moyle (1946) designated the lakes with alkalinity values of 40 mg/L as 'soft' and 40-90 mg/L as 'hard' type, so, Posna *beel* falls under 'soft' type.

The DO level was found to range from 6.6-9.6 mg/L, which is within the limit of Bangladesh standard (>5.0 mg/L) for fish culture and drinking purposes (ECR, 1997). Banerjee (1967) reported that 5.0 to 7.0 mg/L DO content of water as fair or good whereas waters having less than 5.0 mg/L as unproductive. Boyd (1992) concluded that dissolved oxygen <1 mg/L is lethal for fish biota if the exposure lasts longer than a few hours while at DO values of 1-5 mg/L, a fish survives, but reproduction is poor and growth is very slow if exposure is continuous and at DO > 5 mg/L, fish reproduce and grow normally.

The BOD values ranged from 2.7 to 5.4 during winter and post monsoon, respectively, the highest values might be due to maximum biological activities of the microorganisms while the lower values were due to lower biological activities at low temperature during winter Palharya *et al.* (1993) reported that seasonal variation in the value of BOD appears to be a function of changes in the degree of dilution, quantity of organic matters and activities of microorganisms carrying out decomposition of carbonaceous and nitrogenous matter. The COD values showed almost similar pattern of variation as BOD probably due to the same reasons. The Eh values as recorded in the present study indicate that the water of the *beel* under study had a moderate load of organic matter throughout the year. On the basis of the classification of hardness given by Sawyer and Catry (1967), the water of the studied *beel* falls under the soft type and within the Bangladesh standard (200-500 mg/L for drinking water (ECR, 1997).

Table 1 Seasonal variation in physicochemical parameters in water of the Posna *beel*

Parameters	2003-2004				2004-2005			
	M	PM	W	S	M	PM	W	S
Temperature (^oC)	31.0	30.0	16.0	30.00	32.00	30.00	20.00	33.00
Transparency (cm)	148.0	50.0	189.0	25.00	120.00	44.00	92.00	42.00
Total solids (mg/L)	70.00	119.00	7.00	100.00	123.00	106.00	16.00	110.00
pH	7.60	7.90	7.50	7.20	8.00	7.50	7.30	6.80
Free CO_2 (mg/L)	10.00	11.00	5.00	11.00	5.00	10.00	10.00	13.00
Alkalinity (mg/L)	34.00	28.00	51.00	34.00	34.00	34.00	51.00	34.00
DO (mg/L)	6.60	8.20	9.60	8.30	8.00	8.60	8.00	7.10
% sat O_2 (mg/L)	88.00	104.00	98.00	107.00	109.00	11.00	88.00	101.00
BOD (mg/L)	4.00	5.40	2.70	4.30	4.30	4.10	3.50	4.70
COD	6.90	7.50	5.20	8.10	6.80	6.70	5.80	7.80
'P'COD-BOD (mg/L)	2.70	2.10	3.10	3.70	2.50	2.00	2.30	3.10
Eh (mv.)	0.50	0.48	0.50	0.59	0.40	0.40	0.50	0.25
rH_2	29.00	32.00	32.00	32.00	31.00	32.00	32.00	32.00
Total Hard (mg/L)	60.00	51.00	58.00	68.00	65.00	58.00	55.00	74.00
Cl^- (mg/L)	26.00	29.00	30.00	31.00	25.00	28.00	30.00	31.00
NH_3 (mg/L)	0.06	0.05	0.03	0.01	0.07	0.03	0.01	0.04
NO_3. N (mg/L)	0.48	0.25	0.22	0.15	0.40	0.2o	0.15	0.26
PO_4. P (mg/L)	4.80	4.30	2.60	5.3	4.70	4.6o	2.80	4.25

M = Monsoon, PM = Post-monsoon, W = Winter, S = Summer

Average chloride content of the Posna *beel* water was 29.15 mg/L indicating that the water was not polluted. Dhakar (1979) reported that chloride contents between 45 and 122 mg/L indicates medium pollution and that between 60 and 200 mg/L indicates heavy pollution. The levels of ammonia (0.01-0.07 mg/L) and nitrate (0.15-0.48 mg/L) were very low. Comparatively high concentration of phosphate (2.6-5.3 mg/L) was found in all seasons during the study period. The highest

concentration of phosphate 5.3 mg/L) in summer ’04 was probably due to high decomposition rate of aquatic weeds and use of TSP fertilizer in the adjoining paddy fields.

Nutrients in beel sediment

The physicochemical properties of *beel* sediment are shown in Table 2. Both heavy metal and pesticide pollutants have a tendency to bind organic and inorganic solids and eventually sink to the bottom that can subsequently release toxic substances back into the water if disturbed causing harmful effects on fish and other aquatic organisms. Polluted soils pH and mineral concentration in soils have a direct effect on the acidity and availability of toxic metal ions in water. The sediment pH of Posna *beel* ranged from 4.33 to 5 33 with an average of 4.85±0.5 indicating its medium acidic nature. Benerjee (1967) reported that pH values of 6.5 to 7.5 were feeble acidic to slightly alkaline and considered as productive. The organic matter content in the Posna *beel* sediment varied from 3.84 to 6.25% with an average of 4.75±1.3%, the higher accumulation of organic matter was probably due to the decomposition of compounds to different degrees. Total nitrogen content ranged from 0.24 to 0.26% with an average of 0.25±0.02% which was at medium level while the available phosphorus content ranged from 1.04 to 27.05 meq/100 g with an average 10.47±14.40 meq/100 g, the higher amount (27.05 meq/100 g) was recorded in the summer due to high decomposition of aquatic weeds and run-off water from the surrounding *boro* fields where inorganic fertilizers were applied. Sulfur, copper, iron and manganese were at very high level while zinc was at medium level. Only boron was at optimum level in the *beel* sediment (Table 2).

Plankton diversity

Shannon-Wiener biodiversity index shows that the mean plankton species diversity in the Posna *beel* was higher during monsoon and post-monsoon periods and lower during winter and summer (Fig. 3).

Shannon-Wiener biodiversity index showed higher species diversity of phytoplankton in Posna *beel* in both the years. However, species diversity abruptly reduced during winter ’04 and summer’05 probably due to phytoplankton bloom. The mean abundance of phytoplankton was found to become higher during winter ’04 and lower during monsoon.

Table 2 Physico–chemical properties of sediment of the Posna *beel*

Name of Elements	M	W	S	Mean	Comments[1]
pH	5.33	4.33	4.90	4.80	Medium
Organic Matter (%)	3.84	4.17	6.25	4.70	High
Total Nitrogen (N), %	0.26	0.24	0.26	0.20	Medium
Phosphorous (P), µg/g	3.32	1.04	27.05	10.40	Very Low
Potassium (K), Meq/100g	0.35	2.15	0.13	0.80	High
Sulphur (S), µg/g	54.00	30.81	68.90	51.20	Very High
Sodium, meq/100 g	0.12	0.35	0.04	0.17	-
Calcium, meq/100 g	7.33	5.16	6.30	6.20	High
Magnesium, meq/100 g	2.56	2.00	1.83	2.10	Very High
Boron, µg/g	0.45	0.44	0.84	0.57	Optimum
Copper, µg/g	10.24	11.63	8.00	9.90	Very High
Iron, µg/gm	417.00	418.66	440.00	422.00	Very High
Manganese, µg/g	55.63	23.93	59.00	46.10	Very High
Zinc, µg/g	1.23	1.31	1.53	1.36	Medium

[1]Based on GoB standard (BARC, 1997), M = Monsoon, W = Winter, S = Summer

Zooplankton diversity indices were also found to be higher in monsoon and lower in winter in 2004.

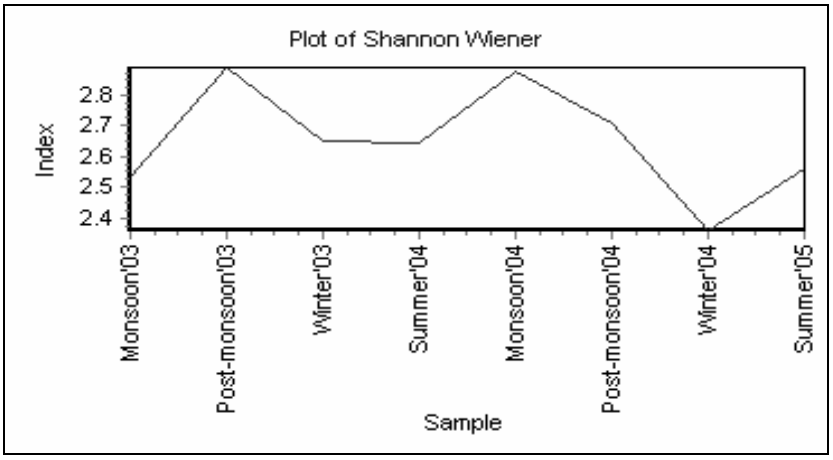

Fig. 3. Estimates of H′ (Shannon-Wiener) as function of seasons during 2003-04.

Multivariate Analysis

Differences in species assemblage among seasons were tested for phytoplankton. Significant difference in species assemblages during monsoon and dry seasons was found. Ten dominant genera of Phytoplankton were found to contribute 65% to the total abundance of zooplankton during 2003-2005 (Table 3).

Differences in species assemblage among seasons were tested for zooplankton. No significant difference in species assemblages during monsoon and dry seasons was found. Ten dominant genera of zooplankton were found to contribute about 81% to the total abundance of zooplankton during 2003-2005 (Table 4).

Table 3 Contributions of ten dominant genera of phytoplankton in *Posna beel*

Name of genus	Average abundance	Average Similarity	% Contribution	Cumulative %
Chlorella	3226.8	2.31	12.77	12.76
Oscillatoria	498.0	2.14	11.83	24.60
Aphanocapsa	368.5	1.37	7.56	32.16
Cosmarium	144.7	1.20	6.65	38.82
Melosira	352.2	1.05	5.85	44.67
Gleocapsa	178.0	0.84	4.68	49.35
Euglena	129.0	0.81	4.49	53.85
Euastrum	69.2	0.72	4.00	57.85
Phacus	100.4	0.69	3.83	61.68
Unidentified genus	141.0	0.67	3.72	65.41

Table 4 Contribution of ten dominant genera of zooplankton in Posna *beel*

Name of genus	Average abundance	Average similarity	% Contribution	Cumulative %
Diaphanosoma	304.500	5.4723	11.2989	11.299
Cyclops	269.375	5.4291	11.2096	22.509
Diaptomus	232.125	4.6897	9.6830	32.191
Keratella	245.250	4.4918	9.2745	41.466
Heliodiaptomus	224.750	4.0861	8.4367	49.903
Ceriodaphnia	168.375	3.8605	7.9709	57.874
Crustacean larvae	235.750	3.7229	7.6868	65.560
Mesocyclops.	187.875	3.2187	6.6458	72.206
Neodiaptomus	130.375	2.3748	4.9034	77.110
Bosmina	154.125	1.9153	3.9545	81.064

Conclusion

It is revealed from the present study that the physical characteristics of the Posna *beel* were mostly within the Bangladesh standard for fish culture while the chemical and biochemical parameters indicated slightly high organic matter content of biodegradable and non-biodegradable nature which did not reach the pollution level. Concentration level of different water quality parameters were within Bangladesh standard for drinking water quality standard (DWQS) as well. Pesticide residues in the *beel* water and sediment during the study period were in untraceable amount. Therefore, the residual pesticides impact on the aquatic environment of Posna *beel* was very negligible. The phytoplankton- zooplankton ratio (5.2:1) was also indicative of the *beel*'s productive nature.

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